de-Broglie's idea of dual nature of Matter

Louis de Broglie's idea of dual nature of Matter.

The Wave Mechanical Concept Comes in figure when L. de-Broglie(1924) in this thesis suggested that any moving particle, whether microscopic or macroscopic, will be associated with a wave character. It is Called matter waves. Louis de Broglie supported the Dual Nature of electron i.e Particle and Wave nature.

Now, The exactness of classical Mechanics has been replaced by Probability.

Dual Nature of Electron: -

According to Bohr's theory electron posses particle nature and revolving around nucleous in a Circular Orbit.

But de-Broglie pointed out in 1924 that electron like light behaves both as a Material Particle and also as wave.

de-Broglie's Equation: - de-Broglie derived an expression for Calculating the wave length λ of the electron wave. If m be the mass of the electron and it is revolving around nucleous with velocity c.

The velocity and wave length are related with following relation.

$$\lambda = \frac{h}{mc} \qquad \text{---} (1)$$

Where h is plank's Constant $[h = 6.62 \times 10^{-34}$ Jule-sec$]$

$$\lambda = \frac{h}{p} \qquad [\because mc = p]$$

Where p is the momentum of the moving particle

The de-Broglie's relationship may be written as

$$p = \frac{h}{\lambda} \qquad [\because h \text{ is a constant}]$$

$$\text{or} \quad p \propto \frac{1}{\lambda} \qquad \text{---} (2)$$

This equation (2) is another form of de-Broglie's Equation. and it may be stated as follows.

" The momentum of a moving particle is inversally proportional to the wave length of the wave associated with it.

Proof of the de-Broglie's Equation:-

Let us Consider the Case of Photon.
If we consider it to be a wave of frequency ν,
then its energy is given by Plank's quantum theory

i.e Plank Equation

$$E = h\nu \quad \text{--- (i)}$$

where ν is frequency, and related with velocity as

$$c = \nu\lambda \qquad \text{or } c = \nu\lambda \quad \text{--- (ii)}$$

$$\text{or } \nu = \frac{c}{\lambda}$$

If we Consider it as a Particle of mass m, ~~which~~ is moving with velocity c, then its energy 'E' is expressed by Einstein mass energy relation

$$\text{i.e } E = mc^2 \quad \text{--- (iii)}$$

From equation (i) and (iii).

$$E = mc^2 = h\nu$$

$$\text{or, } mc^2 = h\nu \quad \text{--- (iv)}$$

On substituting the value of 'c' from eq^n (ii) in eq^n (iv),

$$m.c.\nu\lambda = h\nu$$

$$\text{or } m.c.\cancel{\nu}.\lambda = h\cancel{\nu}$$

$$m.c.\lambda = h$$

$$\text{or } \lambda = \frac{h}{m.c}$$

$$\text{or } \lambda = \frac{h}{p} \quad [\text{Where } m.c = p]$$

Where

λ = Wave length

h = Plank's Constant $[h = 6.62 \times 10^{-34} \text{ jule-sec.}]$

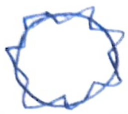
p = momentum of the particle.

Similarity between de-Broglie's Wave-character of the electron and Bohr's Theory

1. Quantisation of Angular Momentum :-

According to de-Broglie the electron is not a Solid Particle revolving round the nucleous in a Circular orbit, but it is a standing wave extended round the Nucleous in a Circular Orbit.

If r be the radius of the Circular Orbit then its Circumference of the Orbit is equal to $2\pi r$.



Wave Continually in Phase

Wave Continually not in Phase.

Now if λ is Wave length (Which is a Wholenumber like, 1,2,3... associated with the electron wave extending round the Nucleous.

For the wave to remain Continually in Phase the Circumference of the Orbit should be integral multiple of Wave length λ.

i.e $$2\pi r = n\lambda \quad \text{—— (ii)}$$

We know, $$\lambda = \frac{h}{mc}$$

Now Substituting the value λ in equation (ii)

$$2\pi r = n \cdot \frac{h}{mc}$$

or $$mcr = n \cdot \frac{h}{2\pi} \quad \left[mcr = n \cdot \frac{h}{2\pi}\right] \text{ —(iii)}$$

It is same as Bohr's Second Postulate.

Electron Can move only in Such Orbits for which the angular momentum must be integral multiple of $\frac{h}{2\pi}$.

Thus de-Broglie relation Provides a theoretical basis for the Bohr's 2nd Postulated.

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Note :- The verification of Wave Nature of Electron by Davision & Germer Expt.